

Exhibit B

TRANSPORT PHENOMENA

**R. BYRON BIRD
WARREN E. STEWART
EDWIN N. LIGHTFOOT**

**Department of Chemical Engineering
University of Wisconsin
Madison, Wisconsin**

**JOHN WILEY & SONS
New York • Chichester • Brisbane • Toronto • Singapore**

BEST AVAILABLE COPY

Preface

BEST AVAILABLE COPY

COPYRIGHT © 1960 BY JOHN WILEY & SONS, INC.

All rights reserved.

Reproduction or translation of any part of this work beyond that permitted by Sections 107 or 108 of the 1976 United States Copyright Act without the permission of the copyright owner is unlawful. Requests for permission or further information should be addressed to the Permissions Department, John Wiley & Sons, Inc.

40 39 38 37 36 35

LIBRARY OF CONGRESS CATALOG CARD NUMBER: 60-11717
PRINTED IN THE UNITED STATES OF AMERICA
ISBN 0 471 07392 X

This book is intended to present the subjects of transport (heat conduction, port (diffusion). In this t phenomena are occurring & said about the molecular continuum approach is of dents, although it should be for complete mastery of the

Because of the current de emphasis on understanding use of empiricism, we feel tl kind. Obviously the subje across traditional departme subject of transport phenom mechanics, and electromag ences." Knowledge of the transport has certainly bec gineering analysis. In add interest to some who are meteorology, and biology.

L CONDUCTIVITY OF SOME
ATMOSPHERIC PRESSURE^a

Substance	Thermal Conductivity <i>k</i> (cal sec ⁻¹ cm ⁻¹ (° K) ⁻¹)
Hydrogen	0.000378
Helium	0.000363
Neon	0.000247
Argon	0.000328
Chlorine	0.000400
Fluorine	0.000703
Sulfur hexafluoride	0.00143
Carbon dioxide	0.00156
Water vapor	0.00160

Handbook of Physics, Thirty-ninth Edition, Chemical Rubber Co., pp. 2257-2259. Corrected data for gaseous substances.

ATMOSPHERIC PRESSURE^a

Substance	Thermal Conductivity <i>k</i> (cal sec ⁻¹ cm ⁻¹ (° K) ⁻¹)
Hydrogen	0.247
Helium	0.290
Neon	0.106
Argon	0.119
Chlorine	0.039
Fluorine	0.037
Sulfur hexafluoride	0.036
Water vapor	0.0196
Carbon dioxide	0.0261
Ammonia	0.0303
Nitrogen	0.1073
Oxygen	0.0956
Hydrogen sulfide	0.0846
Acetylene	0.2055
Propane	0.1809
Butane	0.1596
Methane	0.0617
Acetone	0.0648
Water	0.0675

Vol. 2, Atomic Energy Commission, Washington, D.C. (May, 1955),

TABLE 8.1-4
EXPERIMENTAL VALUES OF THERMAL CONDUCTIVITIES OF
SOME SOLIDS^a

Substance	Temperature <i>T</i> (° C)	Thermal Conductivity <i>k</i> (cal sec ⁻¹ cm ⁻¹ (° K) ⁻¹)
Aluminum	100	0.492
	300	0.64
	600	1.01
Cadmium	0	0.220
	100	0.216
Copper	18	0.918
	100	0.908
Steel	18	0.112
	100	0.107
Tin	0	0.1528
	100	0.143
Brick (common red)	—	0.0015
Concrete (stone)	—	0.0022
Earth's crust (av.)	—	0.004
Glass (soda)	200	0.0017
Graphite	—	0.012
Sand (dry)	—	0.00093
Wood (fir)	—	—
parallel to axis	—	0.00030
perpendicular to axis	—	0.00009

^a Data taken from the *Reactor Handbook*, Vol. 2, Atomic Energy Commission, AECD-3646, U.S. Government Printing Office, Washington, D.C. (May, 1955), pp. 1766 *et seq.*

Substitution in Eq. 8.1-1 then gives

$$k = \frac{QY}{A \Delta T} = \frac{0.717 \times 0.640}{929 \times 2.00} \frac{(\text{cal sec}^{-1})(\text{cm})}{(\text{cm}^2)(\text{°K})} \\ = 2.47 \times 10^{-4} \text{ cal sec}^{-1} \text{ cm}^{-1} (\text{°K})^{-1}$$

For ΔT as small as this, it is usually reasonable to assume that the value of k applies at the average temperature $(T_1 + T_0)/2$, which in this case is 25° C. See Problems 9.F and 9.J for methods of allowing for variation of k with T .

§8.2 TEMPERATURE AND PRESSURE DEPENDENCE OF THERMAL CONDUCTIVITY IN GASES AND LIQUIDS

The scarcity of reliable thermal conductivity data for fluids frequently makes it necessary to estimate k from other data on the given substance. We present here two correlations to aid in such estimation and to illustrate how